5-9-2017

Roll-to-Roll pilot line for large-scale manufacturing of microfluidic devices

Martin Smolka
JOANNEUM RESEARCH FmbH, Austria, martin.smolka@joanneum.at

Anja Haase
JOANNEUM RESEARCH FmbH, Austria

Ursula Palfinger
JOANNEUM RESEARCH FmbH, Austria

Dieter Nees
JOANNEUM RESEARCH FmbH, Austria

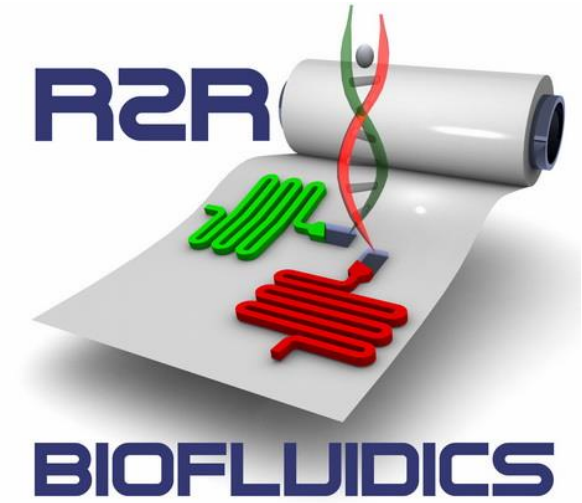
Ladislav Kuna
JOANNEUM RESEARCH FmbH, Austria

See next page for additional authors

Authors
Martin Smolka, Anja Haase, Ursula Palfinger, Dieter Nees, Ladislav Kuna, Jan Hesse, Barbara Stadlober, Sascha. Geidel, Jörg Nestler, Nikolaus Ladenhauf, Andoni Rodriguez, Florian Hasenöhrl, Martin Eibelhuber, Max Sonnleitner, Guggi Kofod, Dan Kofoed, Jan Kafka, Isbaal Ramos, Manuel W. Thesen, Mirko Lohse, Ana Ayerdi, and Nerea Briz

Roll-to-Roll Pilot Line for Large-Scale Manufacturing of Microfluidic Devices

European research project *R2R Biofluidics*

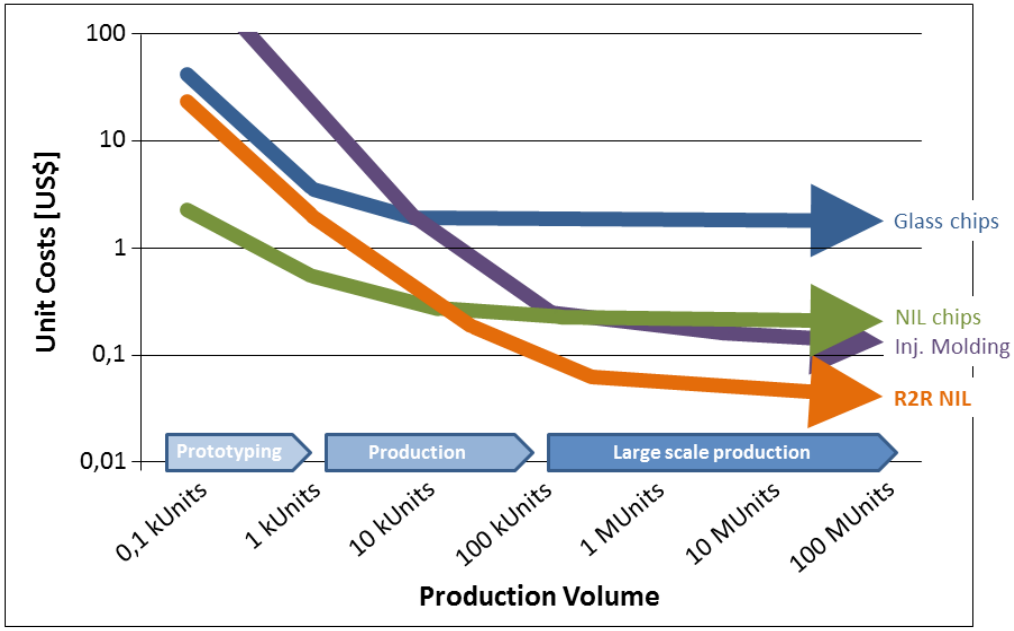


May 09, 2017
Single-Use Technologies II
Tomar, Portugal

Martin Smolka
Joanneum Research – Materials
Weiz (Austria)

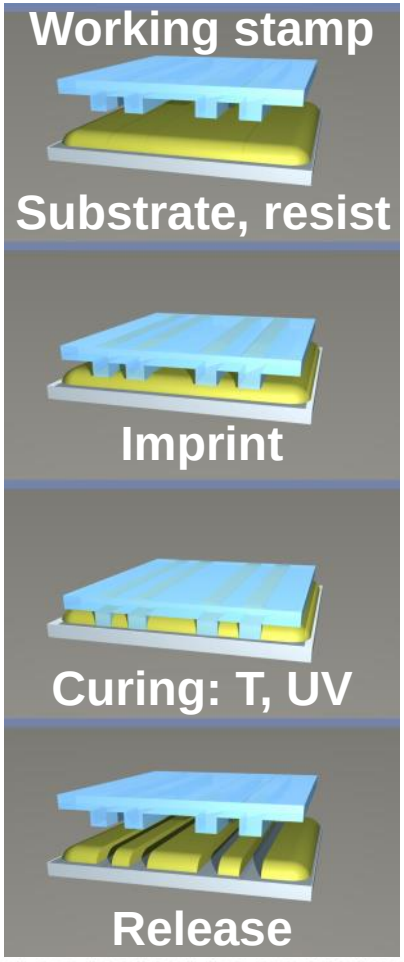
Motivation

- Production of microfluidic chips at lower price than current technologies
- Continuous production on large area instead of batch process



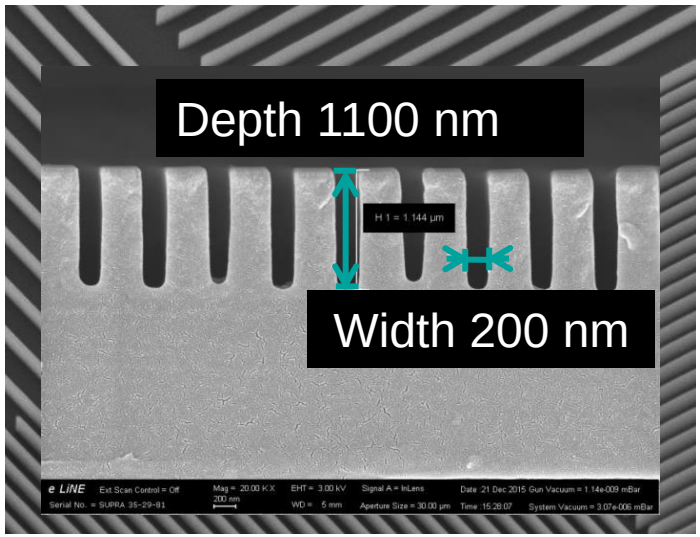
[prices of conventional technologies taken from Yole développement, 2012]

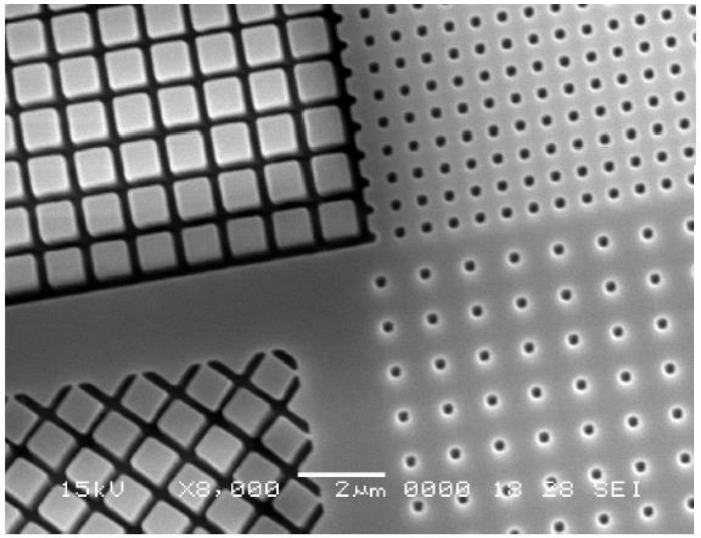
Roll-to-Roll (R2R) based Nano Imprint Lithography



Highlights of Roll-to-Roll based Nano Imprint Lithography

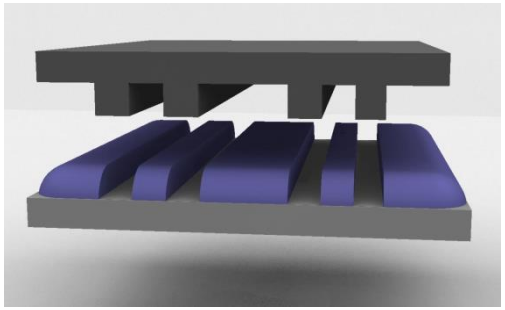
- Micropatterning on large area polymer rolls
- Precise replication of micro- and nano structures
- Functional materials (control of surface chemistry, wettability, …)
- Ease of prototyping

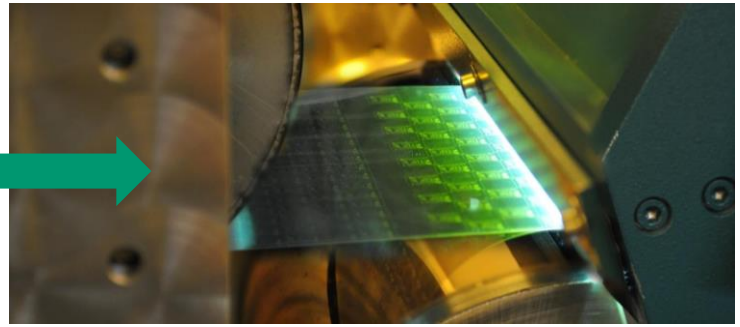


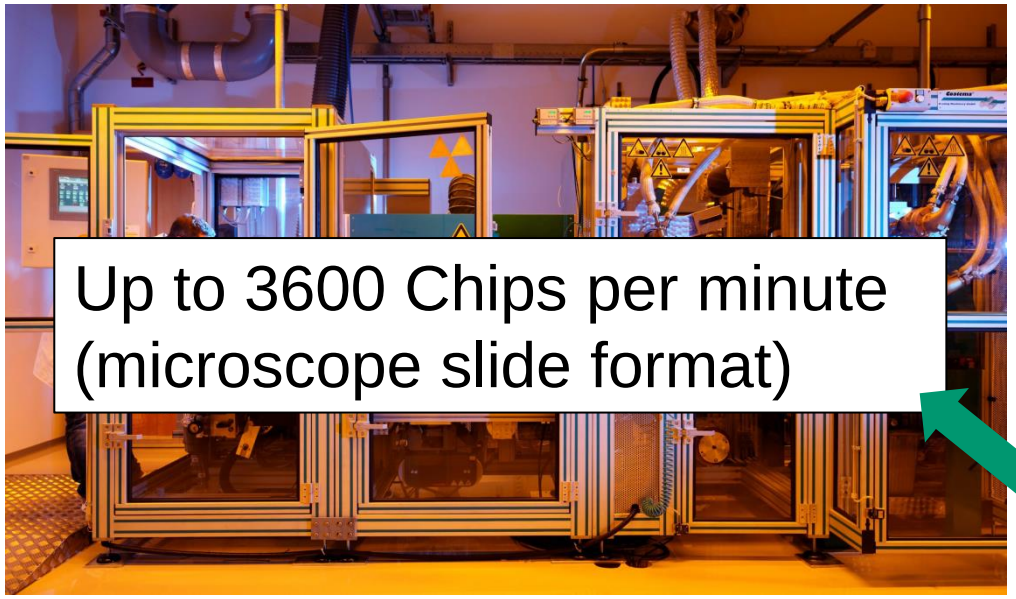


M. Leitgeb, D. Nees, B. Stadlober et al., ACS Nano 10, 4926 (2016)

Roll-to-Roll (R2R) pilot line







R2R pilot line for microfluidic patterning	
Coating	Gravure printing Slot-die
Patterning	R2R UV-imprinting R2R hot embossing
Max. web width	250 mm
Web speed	0.5 – 30 m/min
Laminar flow box	ISO 7

Roll-to-Roll (R2R) pilot line

Pilot line for UV Nano Imprint Lithography

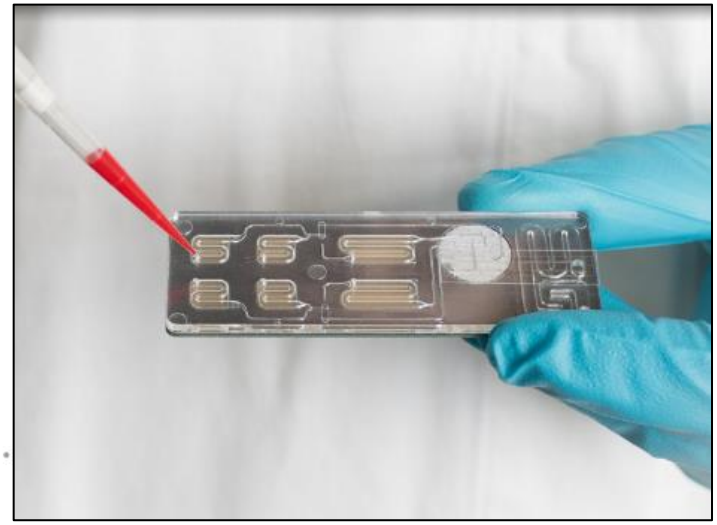
Roll-to-Roll (R2R) pilot line

Assembly of **foils to rigid substrates**, *Biflow systems* (DE)

→ **complex Single-Use devices**

(„Lab-on-a-Chip“ systems, „smart“ Microtiter Plates)

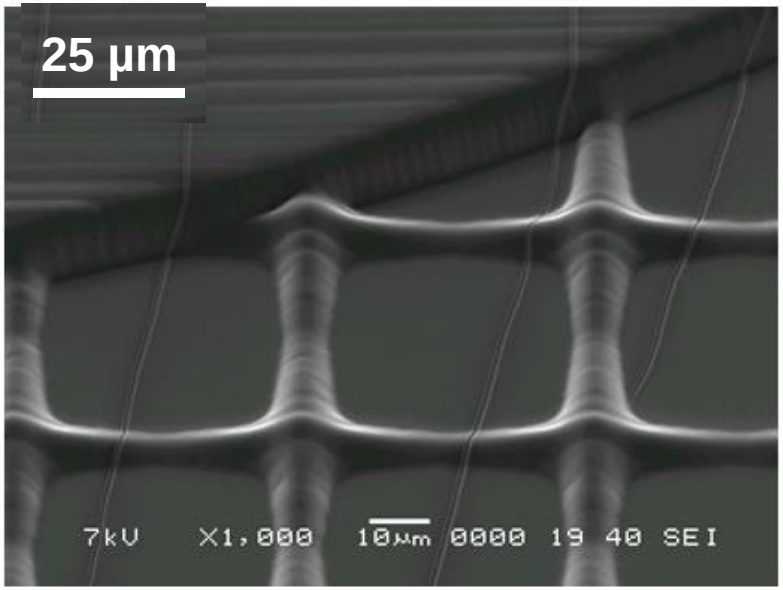
bi.FLOW systems GmbH
biofluidic integration

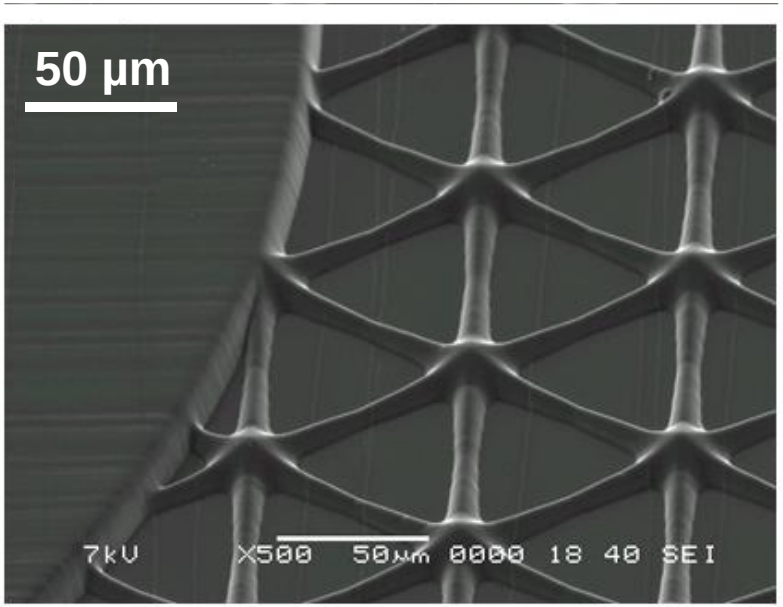


From Nano to Macro: Master prototyping for R2R production

- „2 ½ D“ microfluidic structures by laser lithography
- Flexible design of microfluidic channel network

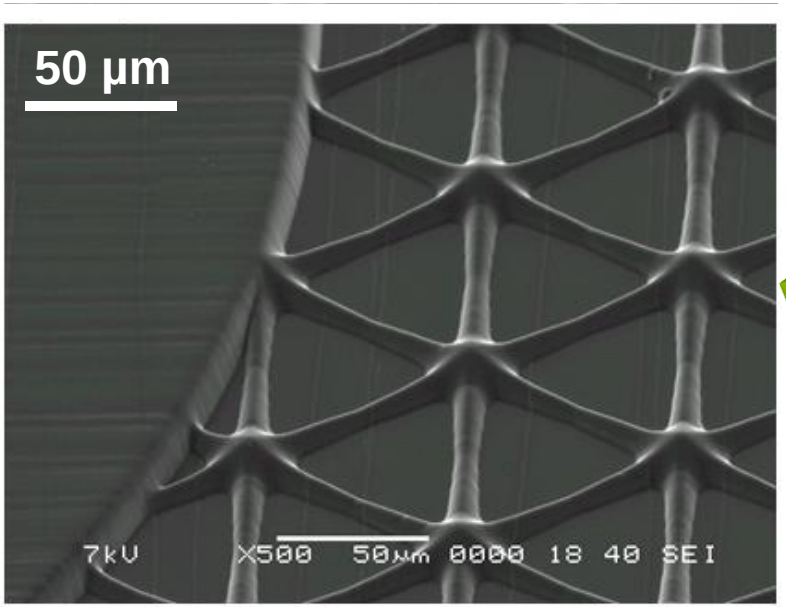
→ precise small area mastering





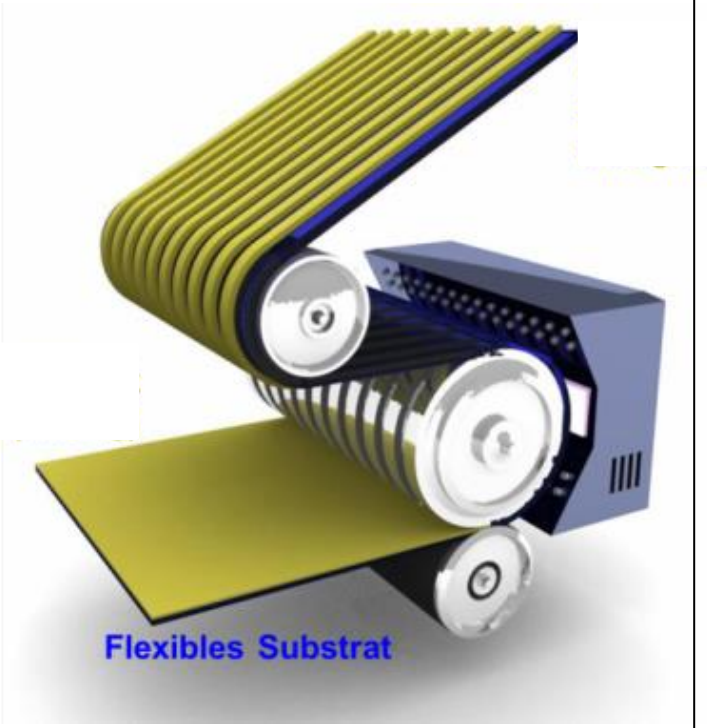
From Nano to Macro: Master prototyping for R2R production

A) Mastering



?

B) Transfer to large area master stamp?

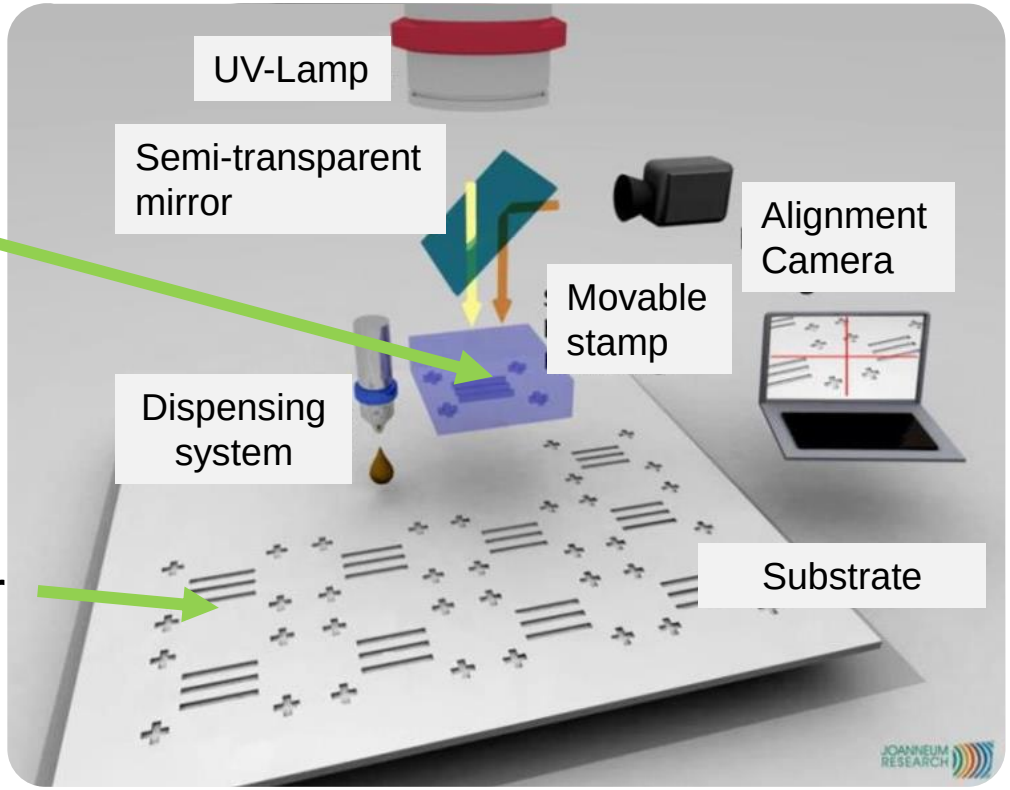


From Nano to Macro: Master prototyping for R2R production

Master replication in step and repeat imprint process

Small scale master structure

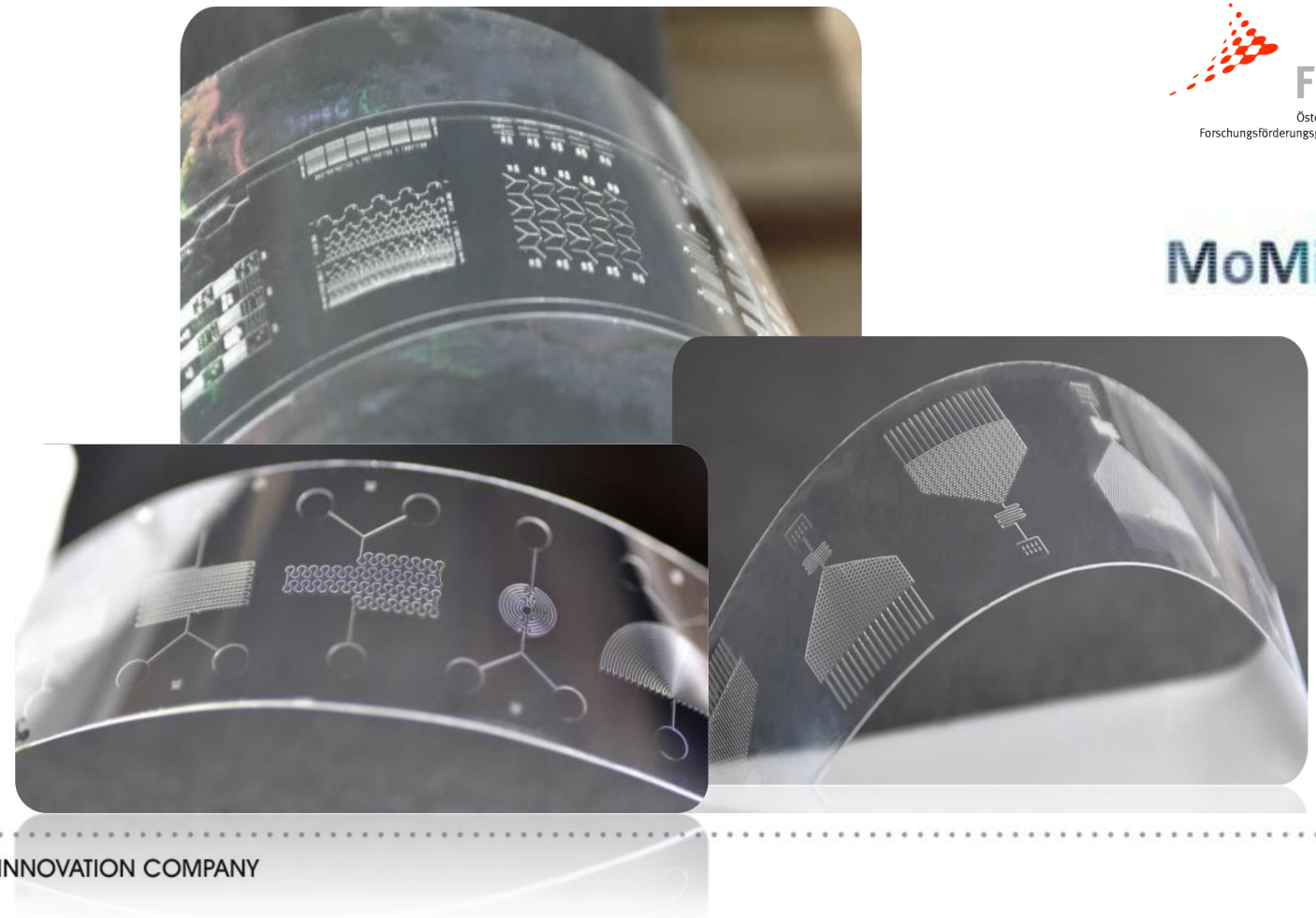
Large area R2R master („shim“)



Step & repeat system
EV Group E. Thallner (AT)

Alternative approach:
Step-And-Repeat Thermal Embossing
Inmold A/S (DK)

Fluidic channels / capillary pumps

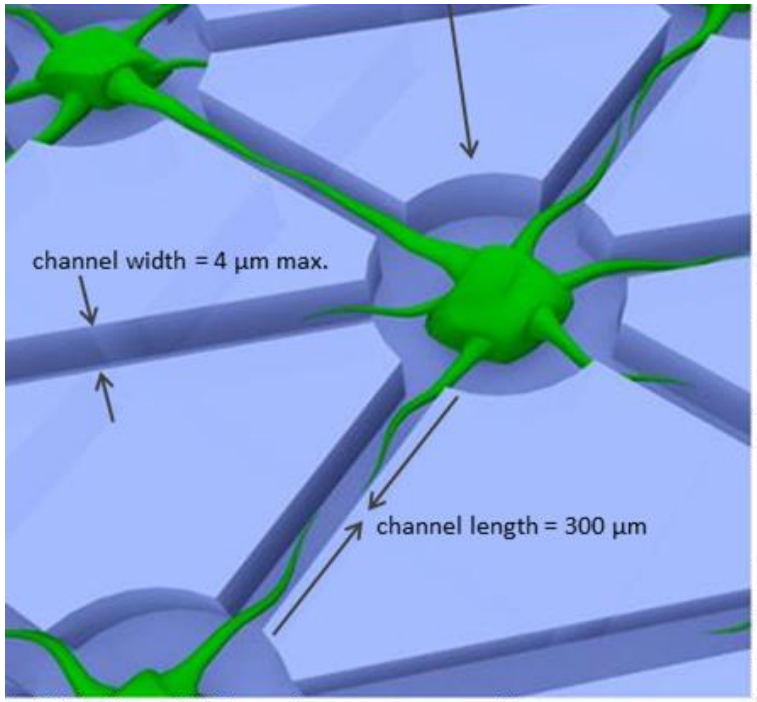


FFG
Österreichische
Forschungsförderungsgesellschaft

MoMiFlu@Foil

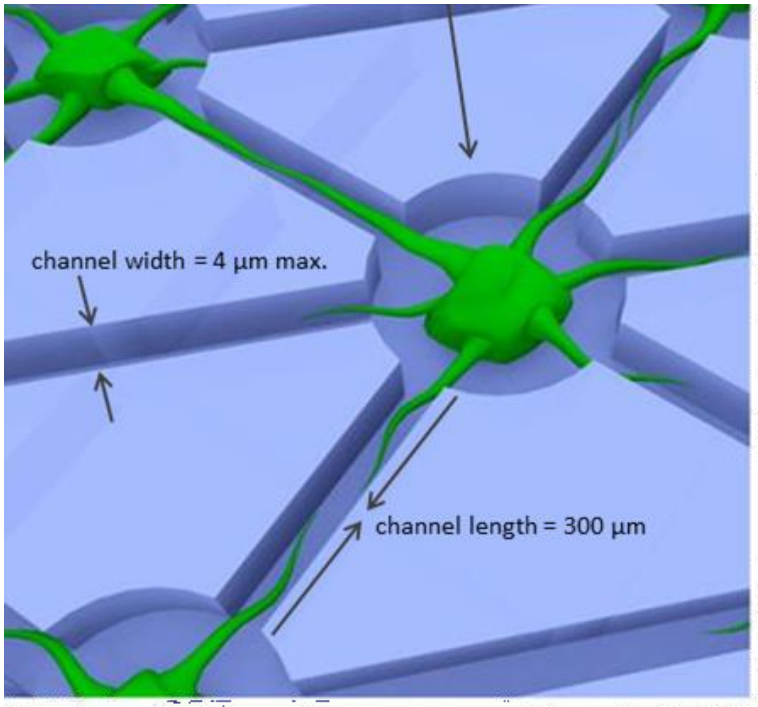
Neuron Cell Culture Device

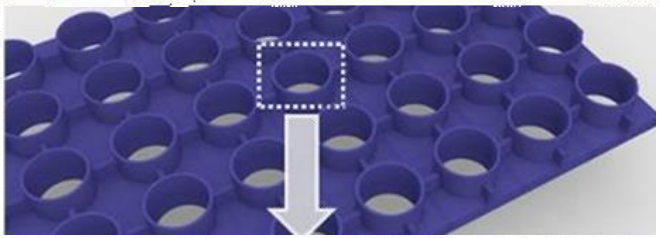
- Roll-to-Roll production of patterned surface with defined cell adhesive areas
- Seeding of neuronal cells
- Formation of neural network in defined microchannels



Neuron Cell Culture Device

- Implementation in microtiter plate for parallel multi-parameter cell studies
- Application for fast drug screening





Innoprot
Speeding up drug discovery

Neuron Cell Culture Device

Injection molding vs R2R nanoimprint?

Injection molding:

Big parts with high topography

R2R Nanoimprint:

Large area nano/micropatterns

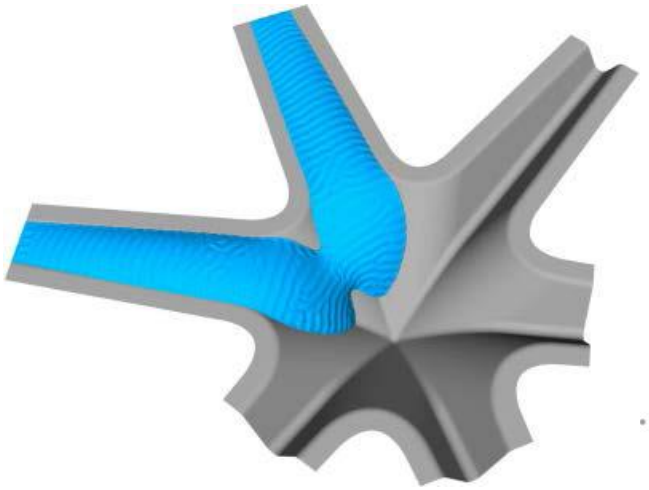
→ **simply combine the best of each technique**

Simulation and Mastering

Coating of channel walls with cell adhesive protein

Step 1: Fill channel networks with protein solution
- „open microfluidics“

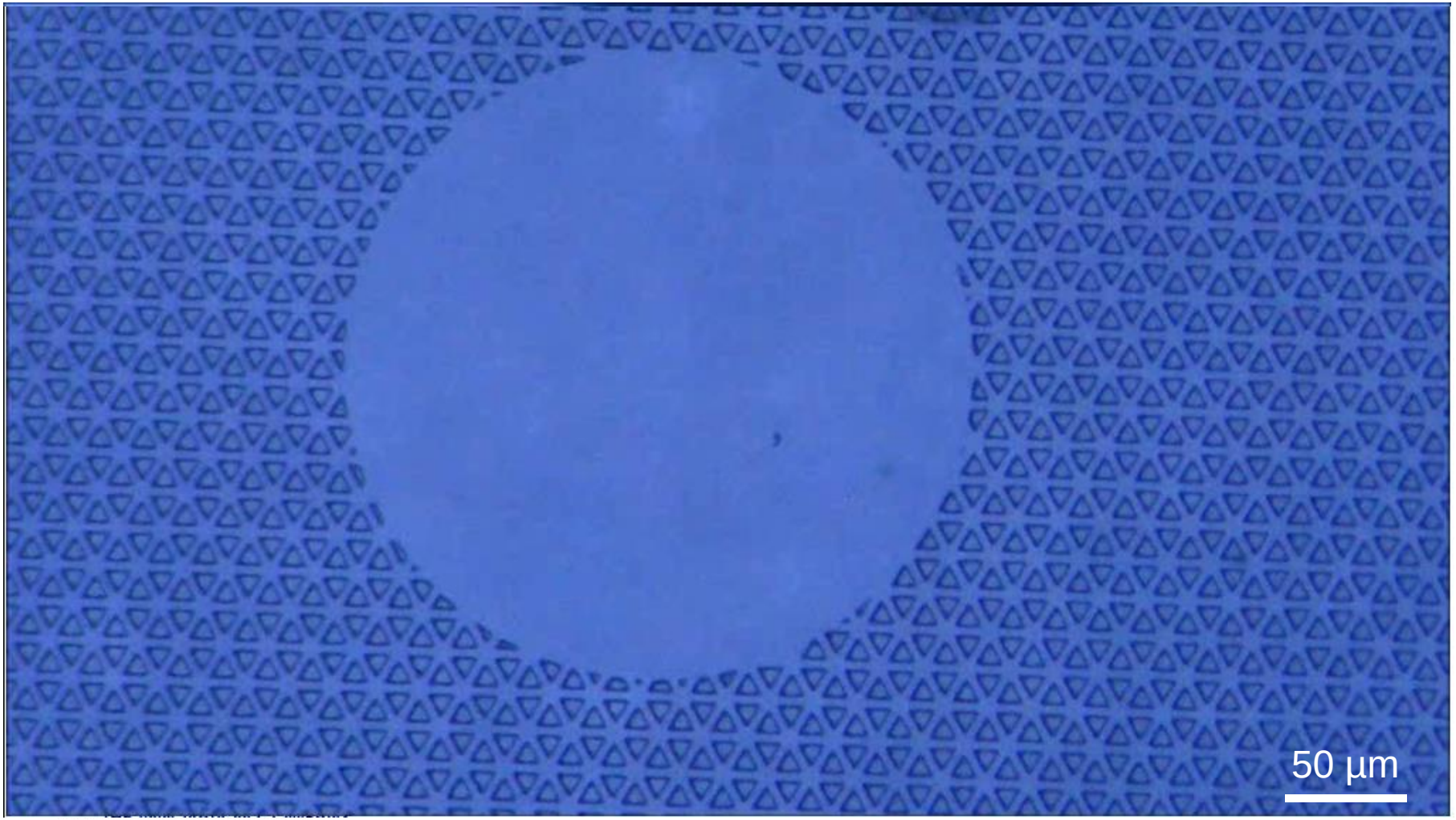
Step 2: Evaporate solvent
- binding of proteins to surface



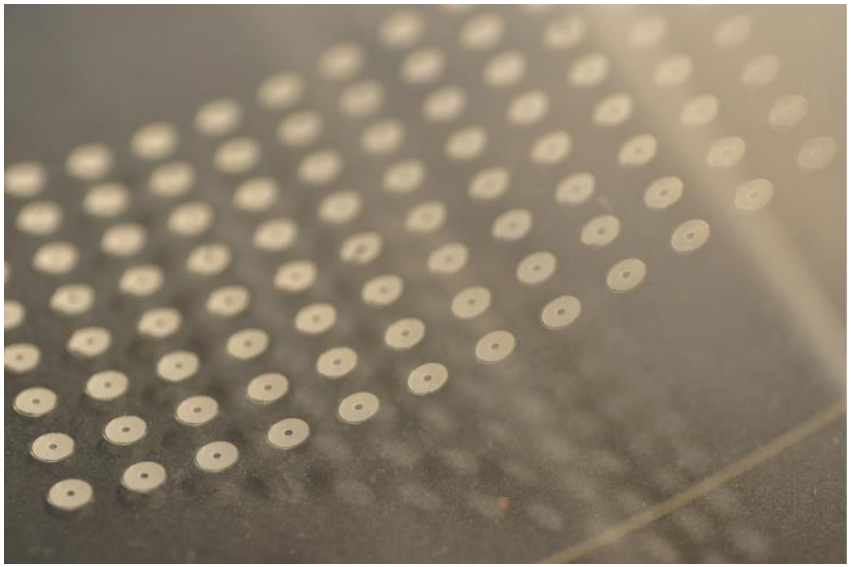
BIONIC.
SURFACE.
TECHNOLOGIES.

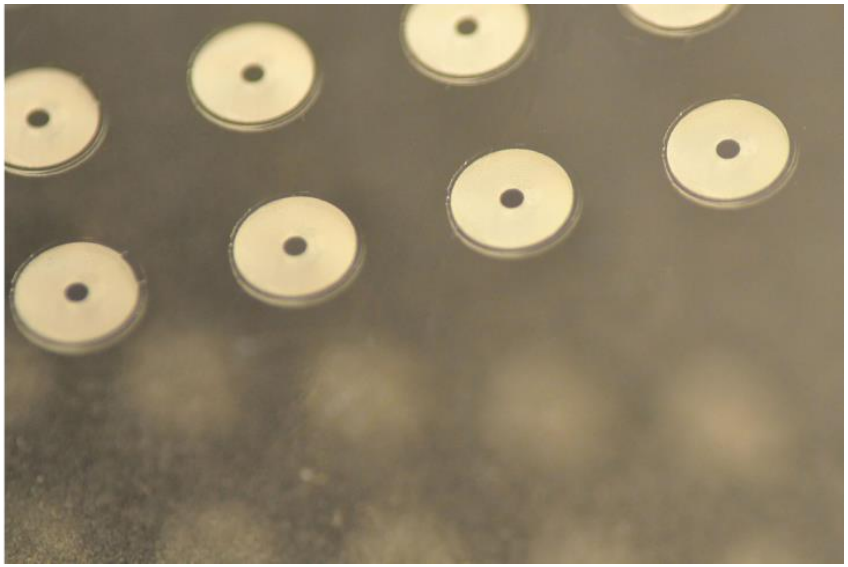
Computational Fluid Dynamics (CFD) simulation of channel filling by capillary forces

Selective coating of imprint structures with cell adhesive substrate (e.g. Poly-lysine, Laminin)



Large area imprints of neuron cell growth pattern





Summary

- Roll-to-Roll Nano Imprint Lithography:
  - Large scale production of microfluidic structures
  - Future technology with low price per unit

- Demonstrator 1:

  In-vitro diagnostics chip with chemiluminescence detection

- Demonstrator 2:

  Cell culture plate for fast drug screening

R2R Biofluidics Consortium

- 10 Partners - 4 European Countries
  - Innoprot S.L. (ES)
  - Tecnalia (ES)
  - InMold BioSystems A/S (DK)
  - BiFlow Systems (DE)
  - micro resist technology (DE)
  - bionic surface technologies (AT)
  - BioNanoNet (AT)
  - EV Group E. Thallner (AT)
  - Genspeed Biotech (AT)
  - Joanneum Research (AT)

Acknowledgement

A. Haase, U. Palfinger, D. Nees, L. Lasave, L. Kuna, S. Jauck, M. Celikic, P. Tören, M. Smolka, J. Hesse, S. Geidel, J. Nestler, N. Ladenhauf, F. Hasenöhrl, A. Rodriguez, M. Eibelhuber, M. Sonnleitner, I. Katzmayr, M. Vogl, J. Kafka, D. Kofoed, G. Kofod, I. Ramos, M. Lohse, M.W. Thesen, N. Briz, A. Ayerdi, G. Bijelic, S. Köstler and B. Stadlober

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 646260.

Thank you for your attention